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CATHODE DEVELOPMENT STUDIES

for the

MARSHALL SPACE FLIGHT CENTER

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ILLUSTRATIONS

1. INTRODUCTION

An appreciable portion of the January work period was spent in the planning of experiments and establishing techniques for cathode evaluation studies. The objective of this work is the determination of optimum cathode materials and geometries for use in a (bombardment type) ion source for extra-terrestrial applications. A major part of the effort under this program will be devoted to life tests since reliability is considered a more important cathode property than emissivity at the present time.

The materials evaluation program will be directed toward seeking a "figure of merit" for a given cathode type which can then serve as a design criterion for source applications. The operating environment in which these tests are conducted will be selected to simulate closely that encountered in the bombardment type engine working on a mercury feed.

2. CATHODE TYPES AND EVALUATION CRITERIA

The Philips type impregnated tungsten dispenser cathode will be studied first. Cathodes of three different porosities have been ordered with three cathodes constituting each sample. The individual cathodes of each sample will be tested at different current densities in a mercury discharge; i. e., each will be operated at successively higher emitter surface temperatures. By plotting current density vs. time at constant arc drop and pressure, performance curves will be obtained from which an effective lifetime may be determined arbitrarily defined as that time at which the cathode emission has fallen to 60% of its initial output. With the results of all three samples available, the emissivity in amperes/cm^2 can then be related to the demonstrated lifetime and porosity for simulated source conditions. A figure of merit will result in terms of

ampere hours per unit emitter surface area normalized by the amount of emitting material available per unit surface area. This latter density may be computed from the known porosity of the cathode. This figure of merit will likely be nearly constant for a specific type of cathode under reasonable operating temperatures.

A typical planar impregnated cathode of the Philips type is shown in Figure 1. These are available in diameters of up to six inches. The design of reliable heaters for cathode diameters greater than those normally used (0.125") poses some problems. As a result, studies will be conducted with cathodes of the size shown in Figure 1 as ofher work has demonstrated successful extrapolation of the results obtained with this geometry to cathodes of up to two inches in diameter. These smaller units are "off-the-shelf" items and have obvious economic and experimental advantages.

3. EXPERIMENTAL APPARATUS

The following requirements were first reviewed in designing the test vessels:

1) the cathodes must be conditioned at not more than 5×10^{-7} torr partial pressure of air
2) the test vessel must provide an isolated environment for each cathode under test
3) strict temperature regulation of the vessels must be possible for control and gauging of the working vapor pressure
4) the vessel must permit optical access to the emitter surface for optical pyrometric measurements.

A number of test chambers were considered and the configuration of Figure 2 is considered suitable. Each cathode is mounted in the pyrex tube and sealed on a glass manifold. The tube will then be baked

during evacuation, the cathode conditioned and the tube filled in a manner similar to that used for mercury arc rectifiers. The tube is then pinched off. Sufficient gettering will be provided to maintain the partial pressure of any gases evolved after cathode conditioning below 5×10^{-7} torr. The sealed tube is then placed in an oil bath and connected to the electrical supplies as illustrated in Figure 3.

4. TEST PROGRAM

During the next work period, emphasis will be placed on the development of testing techniques and fabrication of a small lot of these mercury filled "diodes". The glass manifold and bakeable system will be assembled. The first shipment of the glass test chambers will be delivered. Modified samples of the standard .125 inch dispenser cathode will be procured for the initial test work.